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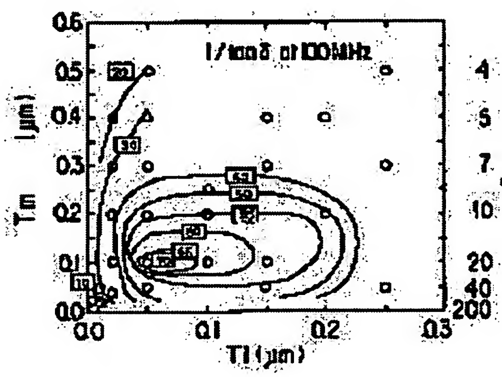
(54) MAGNETIC CORE FOR MICRO MAGNETIC ELEMENT

(57)Abstract:

PURPOSE: To provide a magnetic core for micro magnetic element of high effective magnetic permeability, in which high-frequency losses are decreased significantly compared with the conventional one.

CONSTITUTION: A magnetic core for micro magnetic element is composed of a multilayered soft magnetic film constituted by alternately laminating magnetic metallic films and insulator films, with the magnetic metallic films 0.01-0.3 μm thick and the insulator films 0.02-0.25μm thick.



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CLAIMS

[Claim(s)]
[Claim 1] The micro magnetic cell core characterized by being in the range whose metal magnetic-substance thickness is 0.01 micrometers - 0.3 micrometers, and whose insulator thickness is 0.02 micrometers - 0.25 micrometers in the soft magnetism multilayers which the metal magnetic-substance film and the insulator film turn into from the structure by which the laminating was carried out by turns.
[Claim 2] The micro magnetic cell core according to claim 1 where it has uniaxial magnetic anisotropy and easy-axis lay length is characterized by consisting of one piece or some which 200-micrometer or more strip-of-paper-like metal magnetic-substance film it is [film] 500 micrometers or less became independent of.

[Translation done.]

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DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Industrial Application] This invention relates to the micro magnetic cell core in the RF magnetic cell which operates by the RF which lowers loss of a micro core.
[0002]
[Description of the Prior Art] Miniaturization thin film-ization of a magnetic cell is called for with RF-izing of a functional device. It is known well that the value of a performance index Q other than an impedance or an inductance is important for the property that these components are called for. Therefore, it is required for the loss by the RF other than flux density also with the high magnetic-substance film core used for a magnetic cell or permeability to be small. In a magnetic-substance ingredient, a quality factor (1-/tan delta) is defined by mu'/mu" using the value of the real part (mu') of complex permeability, and imaginary part (mu"). Therefore, a loss factor (tan delta) is so small that this value is large. That is, it is a low loss ingredient. In order to lower loss by the RF conventionally, generally resistance of (1) core is enlarged. (2) Make thickness of a core thin. (3) Subdivide a magnetic domain. (4) The laminating of the magnetic-substance film and the insulator film is carried out, and the approach of reducing eddy current loss is taken. However, it was observed by that permeability is high and fixed to a RF as soft magnetic characteristics in a RF field, and the examination about loss by the RF was not made. Although the core characterized by having uniaxial anisotropy is described in the direction of the field which a coil generates about the structure of a thin film core of having been suitable for the RF, and the direction which intersects perpendicularly at JP,4-363006,A, loss of the easy-axis lay length of each core, a core, or a magnetic cell or relation with a performance index Q is not described. Moreover, although it is indicated by JP,2-081373,A in the multilayers which consist of a metal magnetic film / an insulator layer / a metal magnetic film that high permeability is shown in a RF field, about the relation between the RF property of these multilayers, and the dimension of a magnetic film, reference is not made at all. It is not clear in whether it is obtained also in the core where the dimension of a magnetic film was not specified again about the optimal thickness range of the structure of multilayers, i.e., a magnetic film, and an insulator layer, either, but this property was microfilmed.
[0003]
[Problem(s) to be Solved by the Invention] The purpose of this invention is the low loss which was not acquired at a Prior art in a RF field dozens of MHz or more, and is to offer the micro magnetic cell core where effectual permeability is high.
[0004]
[Means for Solving the Problem] This invention attained the above-mentioned purpose with the following means. The 1st means of this invention is characterized by being the strip-of-paper-like magnetic-substance film with which a period consists of 1 and a large number in the soft magnetism multilayers which consist of the metal magnetic-substance film / insulator film / metal magnetic-substance film.
[0005] The 2nd means of this invention is characterized by obtaining low loss multilayers in a RF field dozens of MHz or more by using 0.01 micrometers - 0.3 micrometers of magnetic-substance thickness of the above-mentioned multilayers, and 0.02 micrometers - 0.25 micrometers of insulator thickness.
[0006] With the 3rd means of this invention, the metal magnetic-substance film has uniaxial magnetic anisotropy, and it is characterized by the thing which the magnetic-substance film of the shape of a strip of paper whose easy-axis lay length is 200 micrometers or more and 500 micrometers or less became independent of and for which one or more are constituted more.
[0007]
[Function] This invention offers the micro magnetic cell core which has low loss in a RF field dozens of

MHz or more, when it has uniaxial magnetic anisotropy and easy-axis lay length uses 0.01 micrometers - 0.3 micrometers of magnetic-substance thickness, and 0.02 micrometers - 0.25 micrometers of insulator thickness in multilayers with the magnetic-substance film of the shape of a strip of paper (200 micrometers or more and 500 micrometers or less), or the non-magnetic-material film.

[0008]

[Example] Below, the example of the micro magnetic cell core of this invention is explained. Generally it seldom adhered to the sample dimension for the reasons of sensitometry, the ease of treatment, etc. at magnetic-properties evaluation of the magnetic-substance film, but the thing with a rectangle of 10-20mm was used. An example of the frequency characteristics of the real part (mu') of the complex permeability of the multilayers in this case and imaginary part (mu") is shown in drawing 1 . The multilayers used by drawing 1 carry out the 20-layer laminating of 0.1 micrometers of magnetic-substance (CoFeSiB) thickness, and the 0.05 micrometers of the insulator (SiO2) thickness. In 100MHz, it is mu'=530 and mu"=90. However, as a result of enabling measurement of the RF property at the time of microfilming about the multilayers of the same laminated structure to the minor axis of 0.3mm and major axis of 2mm which are the dimension actually produced to a magnetic cell, as shown in drawing 2 , it found out completely differing from the case of drawing 1 . The values of the complex permeability in 100MHz in this size were mu'=280 and mu"=5. The difference in loss in both RF field is explained. The quality factor (1-/tan delta) in a RF is defined by mu'/mu", therefore it is shown that a loss factor (tan delta) is so small that this value is large. the above -- in measurement by the multilayers of a macroscopic dimension, the big difference has arisen in mu'/mu"=6 and multilayers [which were microfilmed] mu'/mu" =56 and loss. This shows like before that the property of the microfilmed actual magnetic-substance film cannot be grasped by the macroscopic dimension having estimated the magnetic-substance film, when microfilming multilayers in this way and using them for a magnetic cell.

The relation between loss in an example 1 RF field and the laminating configuration of multilayers is described. Drawing 3 is a result about the multilayers of a macroscopic dimension generally used for magnetic-properties evaluation. the figure in drawing -- the ratio of the real part (mu') of 100MHz complex permeability, and imaginary part (mu") -- it is the quality factor for which it asked from mu'/mu". An axis of abscissa is the thickness (Ti) of the insulator (SiO2) film, and an axis of ordinate is the thickness (Tm) of the magnetic-substance (CoFeSiB) film. The number of laminatings (n) is changed so that the total thickness of the magnetic-substance film may be set to 2 micrometers by drawing 3 . The field where a loss factor is small is located to the field in which the magnetic-substance film is thin and the insulator film is thick. the range of this example -- at most -- it was 16. On the other hand, the relation between the magnetic substance in the core of 2mm and microfilming of the minor axis of a stick-shape core, insulator thickness, and a quality factor is shown in drawing 4 . [0.5mm and a major axis] The figure shown all over drawing is the value of a 100MHz quality factor like drawing 3 . From the comparison of drawing 3 and drawing 4 , according to the conventional evaluation approach, in order to obtain the small multilayers of loss, the magnetic-substance film will be thin as much as possible, and, as for the insulator film, a thing 0.2 micrometers or more thick as much as possible will be required. However, in the multilayers of the actually used micro size, that an optimum value is in both the magnetic-substance film and the insulator film changed. namely, -- the microfilmed multilayers -- 0.01 micrometer<Tm <0.3micrometer and 0.05 micrometer<Ti -- < -- a quality factor exceeding 40 in 0.25 micrometers, and indicating a high value to be 70 by Tm=0.01micrometer and about Ti=0.05micrometer began to be seen and required.

Example 2 drawing 5 is the conceptual diagram of the coil mold thin film inductor used for the example 2. It has structure which rolled the surroundings of the rectangle core 13 by lower coil 12b and up coil 12a in the shape of toroidal ones on the insulating substrate 11 through the insulator film which carried out the cure of the resist. The insulator film is omitted by drawing 5 . The excitation direction is the direction of a right angle to the direction of a long form of an easy axis, i.e., direction, of rectangular. In order to narrow core width of face in order that the core of such a thin film inductor may make a demagnetization factor small, and to make eddy current loss small, subdividing a core more using the thin magnetic-substance film, so that the core cross section may be made small has been considered. Drawing 6 is an inductance in 30 and 500 micrometers (L), and the frequency characteristics of a performance index (Q) about core width of face (w). Core configurations are the multilayers which carried out the 30-layer laminating of 0.1 micrometers of magnetic-substance (CoFeSiB) thickness, and the 0.05 micrometers of the insulator (SiO2) thickness. It turned out that the direction in W= 500 micrometers shows a value with large L and Q compared with the case where a magnetic domain is W= 30 micrometers subdivided more. It turns out that subdividing a core recklessly from this result is degrading the core property on the contrary.

The optimal size of an example 3, then core fragmentation was investigated. Drawing 7 is the conceptual

diagram of the coil mold thin film inductor used for the experiment. It has structure which rolled the surroundings of the rectangle core group 14 by lower coil 12b and up coil 12a in the shape of toroidal one on the insulating substrate 11 through the insulator film which carried out the cure of the resist. The insulator film is omitted by drawing 7 . The number (n) of the core where drawing 7 has core width of face (w) is made for nxw to be 1mm. In any case, a major axis is 2mm. The excitation direction is the direction of a right angle to the direction of a long form of an easy axis, i.e., direction, of rectangular. The 20MHz inductance (L) at the time of changing the value of W into drawing 8 , and maximum Qmax of a performance index Change is shown. When core width of face was made small at 200 micrometers or less, the concept of the conventional demagnetization factor showed that fell contrary to the conventional concept and Q was also falling, although L should become large. The range where both L and Q value are large is 200 micrometer<W <500micrometer.

[0009] It turned out that the optimal width of face is in the stick-shape core used for a thin film inductor like the above-mentioned example. Then, the configuration of a multilayers core and the relation of complex permeability were described. In order to make a demagnetization factor small conventionally, improvement in a property of a core has been aimed at by narrowing core width of face infinite. The value of the real part (mu') of the complex permeability at the time of fixing the major axis of a rectangle core with 2mm, and changing a minor axis (W) into drawing 9 and imaginary part (mu") and change of a quality factor (1/tan delta) are shown. Cores are the multilayers which carried out the 30-layer laminating of 0.1 micrometers of magnetic-substance (CoFeSiB) thickness, and the 0.05 micrometers of the insulator (SiO2) thickness. If core width of face is made small, unlike the concept of the conventional demagnetization factor, mu' and mu" will become small at 200 micrometers or less. And since the fall of mu' was large, it turned out that the quality factor (1-/tan delta) is small. The range where 1-/tan delta is large is 200 micrometer<W <500micrometer, without lowering mu' value.

[0010]

[Effect of the Invention] As stated above, according to this invention, the magnetic cell which shows a high performance index in a RF field is obtained by using the small micro core of loss by the RF.

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DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] It is the property Fig. showing an example of the frequency characteristics of the permeability of the macro multilayers for explaining the example of this invention.
[Drawing 2] It is the property Fig. showing an example of the frequency characteristics of the permeability of the micro multilayers for explaining the example of this invention.
[Drawing 3] It is the property Fig. showing an example of the isoplethic curve of the quality factor of the macro multilayers for explaining the example 1 of this invention.
[Drawing 4] It is the property Fig. showing an example of the isoplethic curve of the quality factor of the micro multilayers concerning the example 1 of this invention.
[Drawing 5] It is the conceptual diagram of the inductor of the example 2 of this invention.
[Drawing 6] It is the property Fig. showing an example of the inductance for explaining the example 2 of this invention, and the frequency characteristics of a performance index.
[Drawing 7] It is the conceptual diagram of the inductor of the example 3 of this invention.
[Drawing 8] They are one core width of face w and L for explaining the example 3 of this invention, and the property Fig. showing an example of the relation of Q.
[Drawing 9] It is the property Fig. showing an example of change of permeability to the short form of the strip-of-paper core for explaining the example 3 of this invention.
[Description of Notations]
11 [-- A rectangle core, 14 / -- Rectangle core group.] -- An insulating substrate, 12a -- An up coil, 12b -- A lower coil, 13

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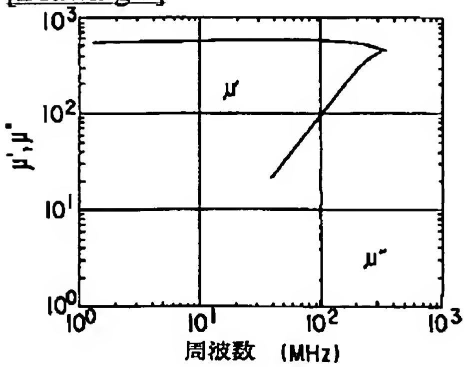
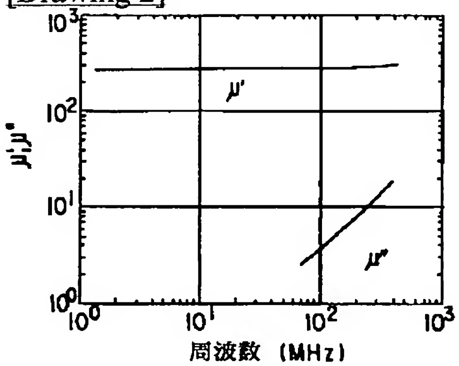
DRAWINGS

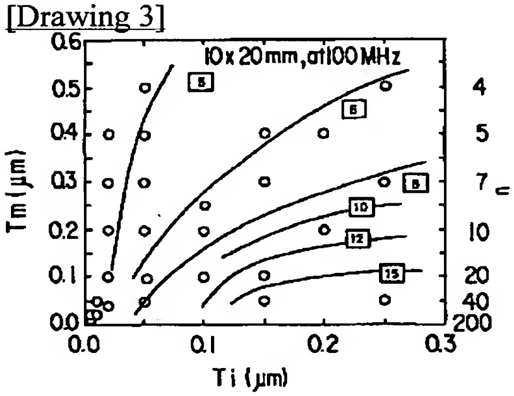
[Drawing 1]



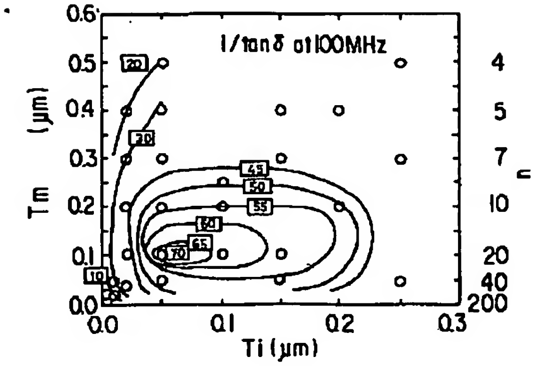
[Drawing 2]



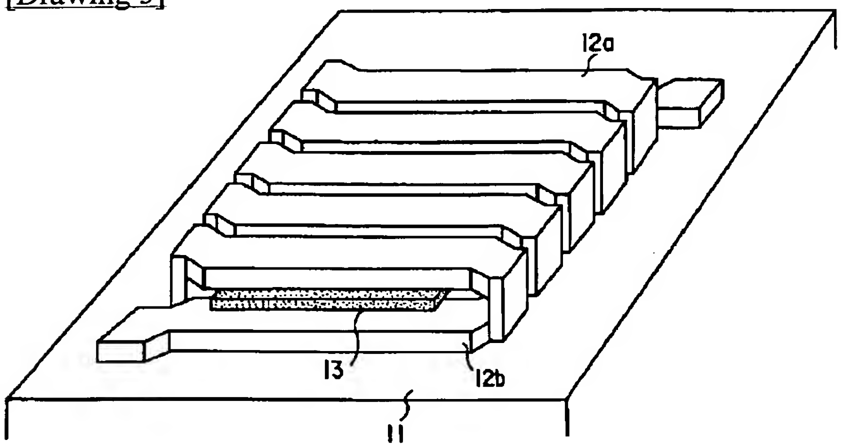
[Drawing 3]



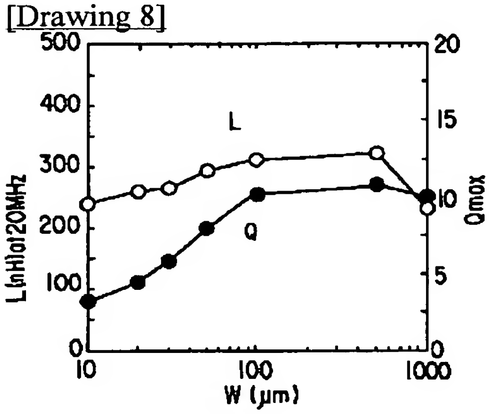
[Drawing 4]



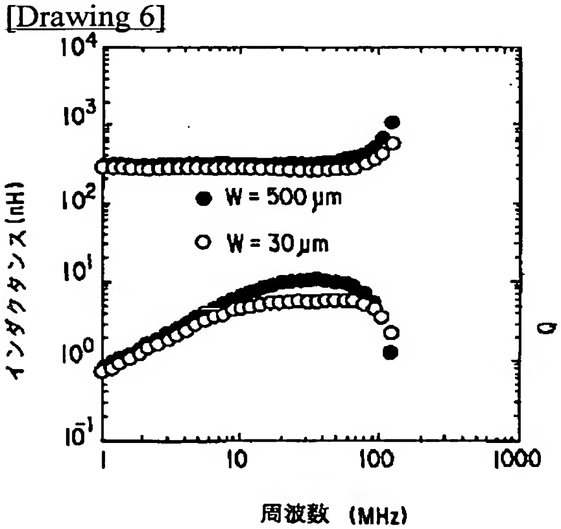
[Drawing 5]



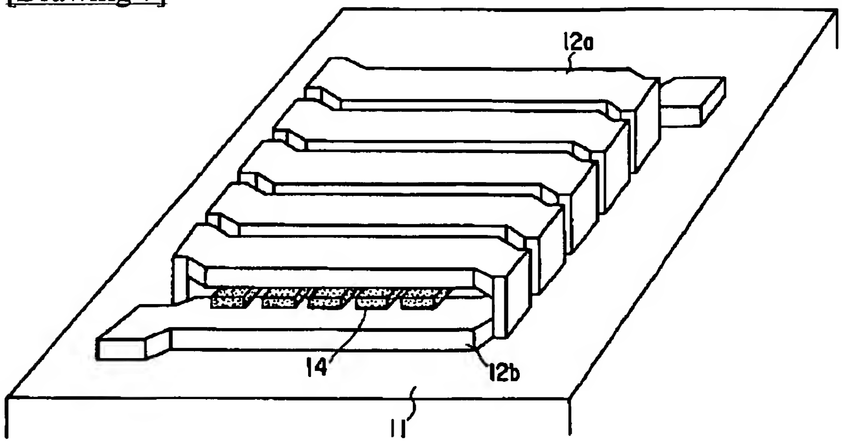
[Drawing 8]



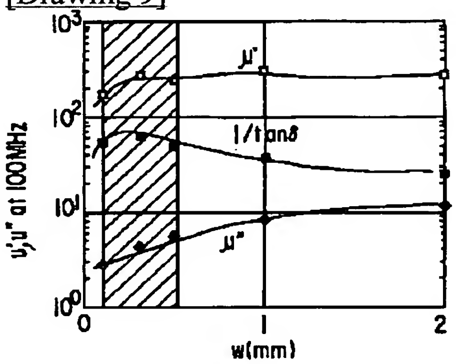
[Drawing 6]



[Drawing 7]



[Drawing 9]



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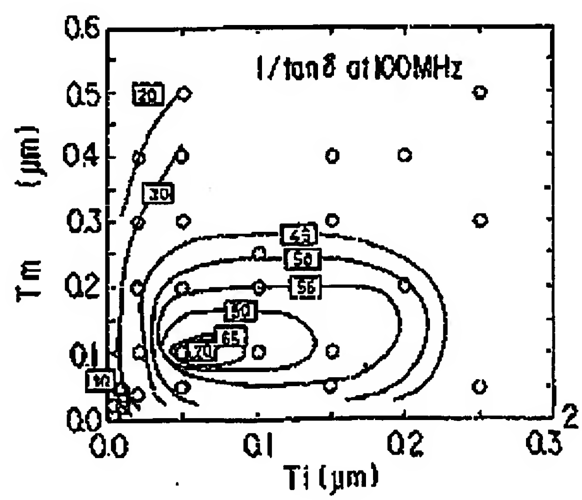
(54)【発明の名称】　マイクロ磁気素子磁心

(57)【要約】
【目的】本発明の目的は、数十ＭＨｚ以上の高周波領域で従来の技術では得られなかった低損失で、かつ実効的な透磁率が高いマイクロ磁気素子磁心を提供することにある。
【構成】本発明のマイクロ磁気素子磁心は、金属磁性体膜と絶縁体膜が交互に積層された構造からなる軟磁性多層膜において、金属磁性体膜厚が０．０１μｍ～０．３μｍ、絶縁体膜厚が０．０２μｍ～０．２５μｍの範囲にあることを特徴とするものである。



【特許請求の範囲】

【請求項１】　金属磁性体膜と絶縁体膜が交互に積層された構造からなる軟磁性多層膜において、金属磁性体膜厚が０．０１μm～０．３μm、絶縁体膜厚が０．０２μm～０．２５μmの範囲にあることを特徴とするマイクロ磁気素子磁心。

【請求項２】　一軸磁気異方性を有し、磁化容易軸方向の長さが２００μm以上５００μm以下である短冊状金属磁性体膜の独立した１個もしくは数個より構成されたことを特徴とする請求項１記載のマイクロ磁気素子磁心。

【発明の詳細な説明】

【０００１】

【産業上の利用分野】本発明は高周波で動作する高周波磁気素子における、マイクロ磁心の損失を下げるマイクロ磁気素子磁心に関するものである。

【０００２】

【従来の技術】機能デバイスの高周波化にともない、磁気素子の小型化薄膜化がもとめられている。これらの素子が求められる特性にはインピーダンスやインダクタンスの他に性能指数Ｑの値が重要であることは良く知られている。従って、磁気素子に用いられる磁性体膜磁心も高い磁束密度や透磁率の他に高周波での損失が小さいことが必要である。磁性体材料において損失係数の逆数（１／tan δ）は複素透磁率の実数部（μ′）と虚数部（μ″）の値を用い、μ′／μ″で定義される。従って、この値が大きいほど損失係数（tan δ）は小さい。すなわち、低損失材料である。従来、高周波での損失を下げるために、一般に、（１）磁心の抵抗を大きくする。（２）磁心の厚さを薄くする。（３）磁区を細分化する。（４）磁性体膜と絶縁体膜を積層して渦電流損を低減する等の方法がとられている。しかし、高周波領域での軟磁気特性として、透磁率が高周波まで高く、一定であることに注目され、高周波での損失についての検討はなされなかった。特開平４－３６３００６号公報には高周波に適した薄膜磁心の構造に関して、コイルの発生する磁界の方向と直交する方向に一軸異方性を有することを特徴とする磁心について述べられているが、各磁心の磁化容易軸方向の長さと磁心または磁気素子の損失あるいは性能指数Ｑとの関係については述べられていない。また、特開平２－０８１３７３号公報には金属磁性膜／絶縁膜／金属磁性膜よりなる多層膜において、高周

ＭＨｚ以上の高周波領域で従来の技術では得られ
た低損失で、かつ実効的な透磁率が高いマイクロ
子磁心を提供することにある。

【０００４】

【課題を解決するための手段】本発明は下記の手
り上記の目的を達成した。本発明の第１の手段は
磁性体膜／絶縁体膜／金属磁性体膜からなる軟磁
膜において、周期が１および多数からなる短冊状
体膜であることを特徴とする。

【０００５】本発明の第２の手段は上記多層膜の
膜厚０．０１μm～０．３μm、絶縁体膜厚０．
m～０．２５μmを用いることにより、数十ＭＨ
の高周波領域で低損失多層膜を得ることを特徴と

【０００６】本発明の第３の手段では、金属磁性
一軸磁気異方性を有し、磁化容易軸方向の長さが
μm以上、５００μm以下である短冊状の磁性体
立した１個または複数個より構成されることを特
る。

【０００７】

【作用】本発明は一軸磁気異方性を有し磁化容易
の長さが２００μm以上、５００μm以下の短冊
性体膜または非磁性体膜との多層膜において、磁
厚０．０１μm～０．３μm、絶縁体膜厚０．０
～０．２５μmを用いることにより、数十ＭＨｚ
高周波領域で低損失を有するマイクロ磁気素子磁
供する。

【０００８】

【実施例】以下に、本発明のマイクロ磁気素子磁
施例を説明する。一般に磁性体膜の磁気特性評価
定感度や扱いやすさ等の理由により試料寸法には
だわらず１０～２０mmの矩形のものが用いられ
た。この場合の多層膜の複素透磁率の実数部（μ
よび虚数部（μ″）の周波数特性の一例を図１に
図１で用いた多層膜は磁性体（ＣｏＦｅＳｉＢ）
０．１μm、絶縁体（SiO_2）膜厚０．０５μ
０層積層したものである。１００ＭＨｚにおいて
５３０、μ″＝９０である。ところが、同じ積層
多層膜について、実際に磁気素子に作製する寸法
る。短径０．３mm、長径２mmにマイクロ化し
の高周波特性の測定を可能にした結果、図２に示
に、図１の場合とは全く異なっていることを見い
た。このサイズでの１００ＭＨｚにおける複素透

のように、マクロな寸法で磁性体膜の評価をおこなってたのでは、実際のマイクロ化された磁性体膜の特性を把握できないことを示している。

実施例1

高周波領域での損失と多層膜の積層構成との関係について述べる。図3は一般に磁気特性評価に用いられてきたマクロな寸法の多層膜についての結果である。図中の数字は100MHzでの複素透磁率の実数部（μ′）および虚数部（μ″）の比μ′／μ″より求めた損失係数の逆数である。横軸は絶縁体（SiO_2）膜の膜厚（T_i）、縦軸は磁性体（CoFeSiB）膜の膜厚（T_m）である。図3で磁性体膜の総膜厚が2μmになるように積層数（n）を変えてある。損失係数が小さい領域は磁性体膜が薄く絶縁体膜が厚い領域にある。本実施例の範囲では高々16であった。一方、図4に、短冊型磁心の短径を0．5mm、長径を2mmとマイクロ化の磁心における磁性体、絶縁体膜厚と損失係数の逆数の関係を示す。図中に示した数字は図3と同様に100MHzでの損失係数の逆数の値である。図3と図4の比較より、従来の評価方法によれば、損失の小さい多層膜を得るには、磁性体膜はできるだけ薄く、絶縁体膜は0．2μm以上のできるだけ厚いことが要求されることになる。ところが、実際に使用するマイクロサイズの多層膜においては、磁性体膜、絶縁体膜双方に最適値があることがかわった。すなわち、マイクロ化した多層膜では、0．01μm<T_m<0．3μm、0．05μm<T_i<0．25μmの範囲で損失係数の逆数が40を越し、またT_m＝0．01μm、T_i＝0．05μm近傍で70と高い値を示すことがみいだされた。

実施例2

図5は実施例2に用いた巻線型薄膜インダクタの概念図である。絶縁基板11上に、短冊形磁心13の周りをレジストをキュアした絶縁体膜を介してトロイダル状に下部コイル12bおよび上部コイル12aで巻いた構造になっている。図5で絶縁体膜は省略されている。励磁方向は短冊形状の長形方向すなわち磁化容易軸方向に対して直角方向である。このような薄膜インダクタの磁心は反磁界係数を小さくするために、磁心幅を狭くし、また渦電流損失を小さくするために薄い磁性体膜を用いて、磁心断面積を小さくするように磁心をより細分化することが検討されてきた。図6は磁心幅（w）を30および500μmの場合のインダクタンス（L）および性能指

そこで磁心細分化の最適サイズを調べた。図7は
用いた巻線型薄膜インダクタの概念図である。絶
11上に、矩形磁心群14の周りをレジストをキ
た絶縁体膜を介してトロイダル状に下部コイル1
よび上部コイル12aで巻いた構造になっている
で絶縁体膜は省略されている。図7は磁心幅（w
する磁心の本数（n）をn×wが1mmになるよ
てある。長径はいずれの場合も2mmである。励
は短冊形状の長形方向すなわち磁化容易軸方向に
直角方向である。図8にWの値を変えた場合の2
zでのインダクタンス（L）および性能指数の最
max の変化を示す。200μm以下に磁心幅を小
ると、従来の反磁界係数の概念からは、Lが大き
はずであるが、従来の概念とは逆に低下し、Qも
ていることがわかった。LおよびQ値が共に大き
は200μm<W<500μmである。

【0009】上記実施例のように薄膜インダクタ
る短冊型磁心に最適幅があることがわかった。そ
層膜磁心の形状と複素透磁率の関係を述べた。従
磁界係数を小さくするために、磁心幅を限りなく
ることで磁心の特性向上を図ってきた。図9に、
磁心の長径を2mmと一定にして、短径（W）を
場合の複素透磁率の実数部（μ′）および虚数部
（μ″）の値および損失係数の逆数（1／tan δ
化を示す。磁心は磁性体（CoFeSiB）膜厚
μm、絶縁体（SiO_2）膜厚0．05μmを3
層した多層膜である。200μm以下に磁心幅を
すると、従来の反磁界係数の概念とは異なり、μ
μ″共に小さくなる。しかもμ′の低下が大きい
損失係数の逆数（1／tan δ）は小さくなってい
がわかった。μ′値を下げずに1／tan δが大き
は200μm<W<500μmである。

【0010】

【発明の効果】以上述べたように本発明によれば
波で損失の小さいマイクロ磁心を用いることによ
周波領域で高い性能指数を示す磁気素子が得られ

【図面の簡単な説明】

【図1】本発明の実施例を説明するためのマクロ
の透磁率の周波数特性の一例を示す特性図である

【図2】本発明の実施例を説明するためのマイク
膜の透磁率の周波数特性の一例を示す特性図であ

【図3】本発明の実施例1を説明するためのマク

ある。

【図７】本発明の実施例３のインダクタの概念図である。

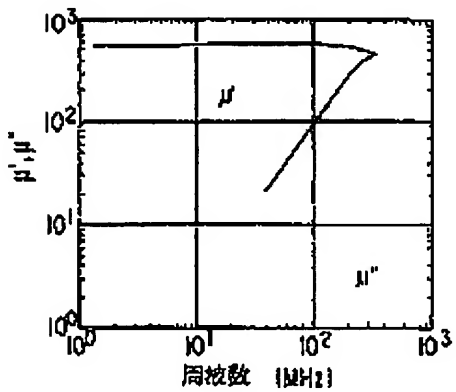
【図８】本発明の実施例３を説明するための１本の磁心幅ｗとＬ、Ｑの関係の一例を示す特性図である。

＊【図９】本発明の実施例３を説明するための短冊短形に対する透磁率の変化の一例を示す特性図で

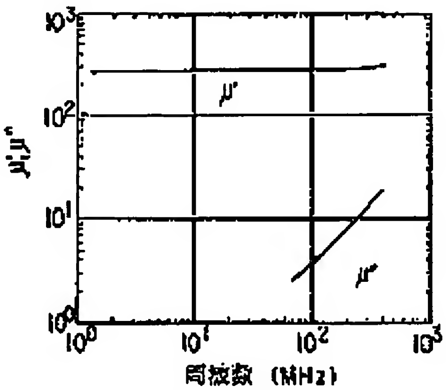
【符号の説明】

１１…絶縁基板、１２ａ…上部コイル、１２ｂ…イル、１３…短冊形磁心、１４…矩形磁心群。

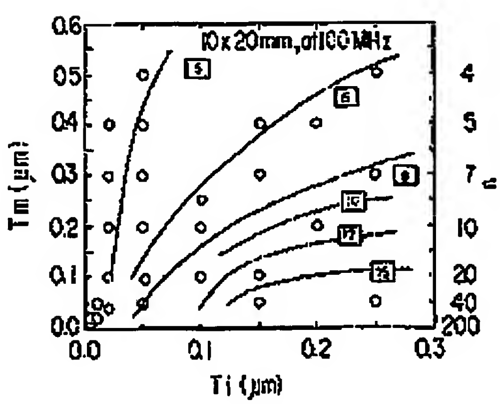
【図１】



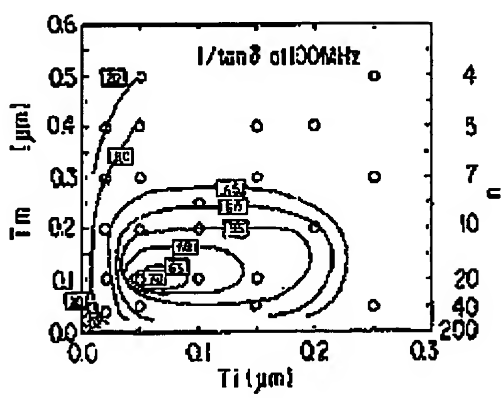
【図２】



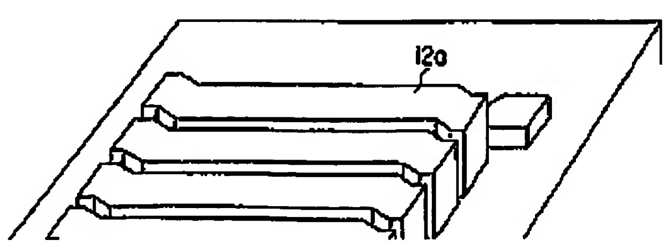
【図３】



【図４】

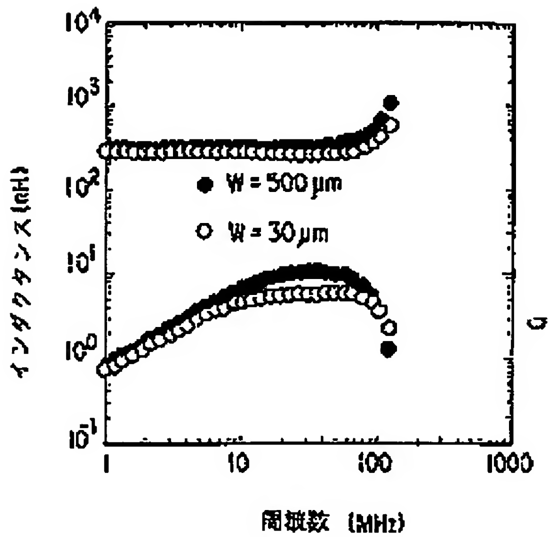


【図５】

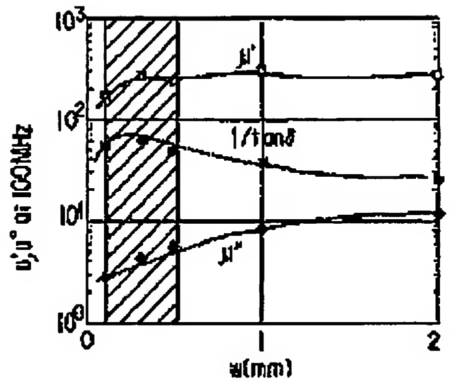


【図８】

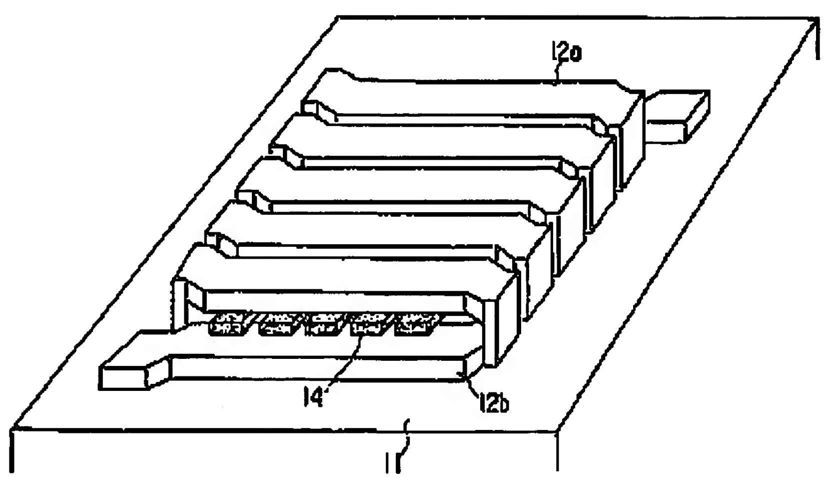
【図6】



【図9】



【図7】



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